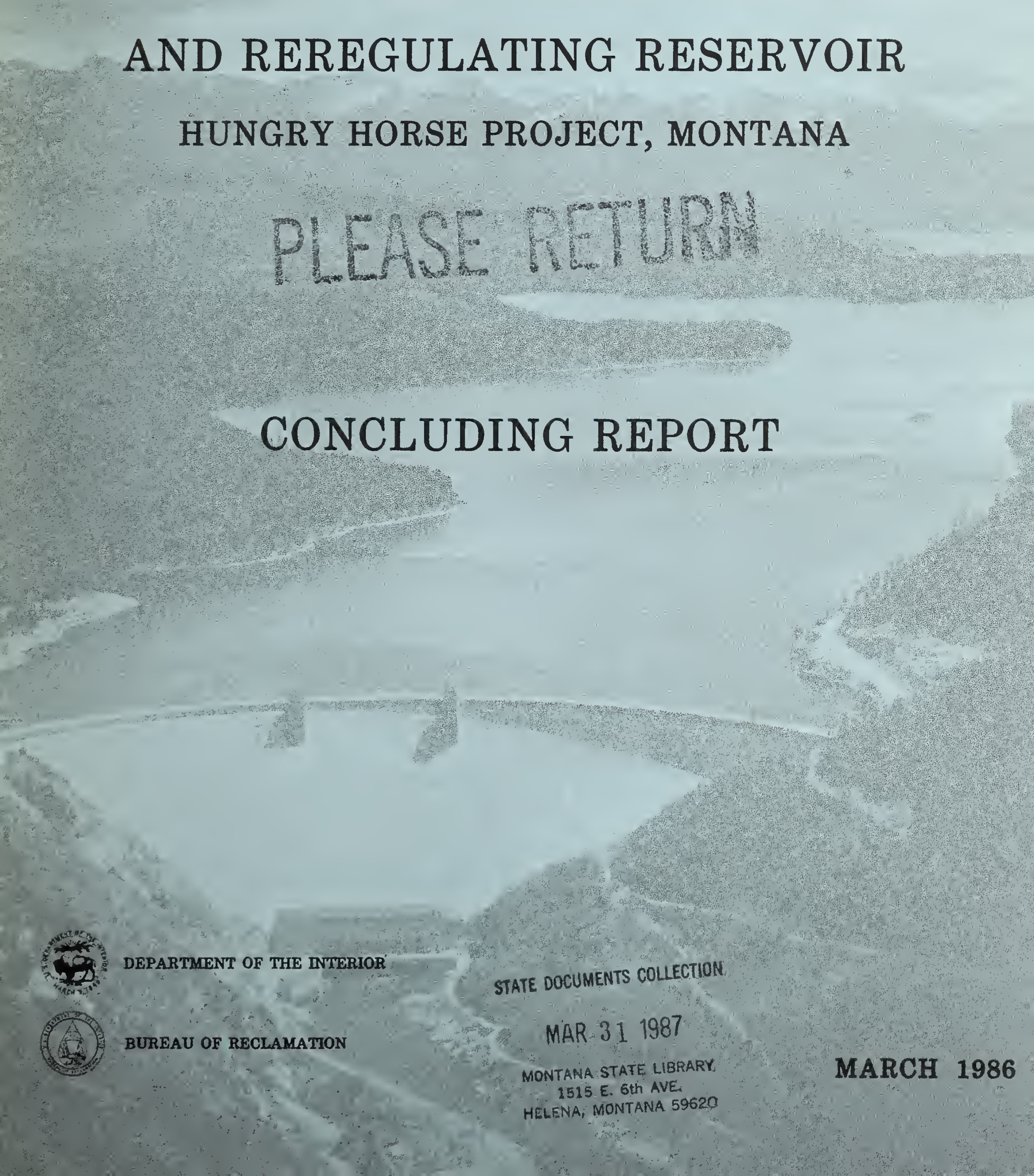


HUNGRY HORSE POWERPLANT ENLARGEMENT AND REREGULATING RESERVOIR

HUNGRY HORSE PROJECT, MONTANA

CONCLUDING REPORT

DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

MARCH 1986

Hungry Horse Powerplant Enlargement and Reregulating Reservoir
Hungry Horse Project, Montana

CONCLUDING REPORT

MARCH 1986

This report was prepared under the authority of Public Law 96-375. Publication of the findings in this report should not be construed as representing either the approval or disapproval of the Secretary of the Interior. The purpose of this report is to provide information on study findings and reasons for concluding the investigation.

Department of the Interior

Bureau of Reclamation

United States Department of the Interior

BUREAU OF RECLAMATION
PACIFIC NORTHWEST REGION
FEDERAL BUILDING & U.S. COURTHOUSE
BOX 043 - 550 WEST FORT STREET
BOISE, IDAHO 83724

IN REPLY REFER TO: PN 735
123.

AUG 5 1986

As part of an inventory of hydroelectric generating potential at Federal dams under its administrative jurisdiction, the Bureau of Reclamation evaluated possibilities for increasing generating capacity at Hungry Horse Dam in Montana. This evaluation led to a feasibility study authorized by Congress. Since you have an interest in the resources of the area, we are enclosing a copy of our March 1986 report on the Hungry Horse study for your information.

The feasibility study concluded that installation of additional, new generating facilities at the dam is not warranted at this time. However, generators now in place will be undergoing a scheduled maintenance rewind in the near future, and the study recommended that the electrical capacity of the powerplant be increased concurrently with the maintenance work. Increasing generator electrical capacity at the time of maintenance rewinding is encouraged on Reclamation projects where existing turbine capacity exceeds electrical capacity under normal operating conditions as it does at Hungry Horse. Current plans are to accomplish this work over the period 1987-91.

A second objective of the study was to investigate potential modifications in Hungry Horse Dam operations that could benefit the Flathead River kokanee fishery. Reclamation assisted in funding fishery studies conducted by State and Federal agencies and participated in riverflow modification tests to assess effects on the fishery. These efforts aided fishery agencies in establishing target streamflow objectives for the Flathead River near Columbia Falls, and now these objectives have been incorporated into the Northwest Power Planning Council's Fish and Wildlife Program. Operating Hungry Horse Dam to assist in meeting target flows will reduce peak energy generation, but the planned generator rewind and uprate program will help recapture this generation.

If you have questions or would like additional information, please write or call David Smith, Hungry Horse study coordinator, at this address attention code 741 or call 208-334-1774 (FTS 554-1774).

Sincerely yours,

Paul D. Rachetto
ACTING
Regional Director

Enclosure

CANADA
UNITED STATES
FLATHEAD RIVER BASIN
MONTANA
KEY MAP
N
MILES
KILOMETERS
GLACIER NATIONAL PARK
Kintla Lake
Bowman Lake
Logging Lake
Lake McDonald
Flathead River
(North Fork)
Middle Fork
Whitefish Lake
Whitefish River
Tally Lake
Ashley Lake
Little Bitterroot Lake
LINCOLN
KOOTENAI NATIONAL FOREST
Stryker
Whitefish
Columbia Falls
West Glacier
Corom
Martin City
Hungry Horse
HUNGRY HORSE DAM
Hungry Horse Reservoir
GREAT BEAR WILDERNESS
CONTINENTAL DIVIDE
KALISPELL
Creston
JEWEL BASIN HIKING AREA
Bigfork
BIGFORK DAM
Somers
Lakeside
FLATHEAD LAKE
Swan Lake
Swan River
South Fork Flathead River
Spotted Bear River
K.N.F.
LOLO NAT'L FOREST
FLATHEAD INDIAN RESERVATION
BIG CREEK DAM
Polson
KERR DAM
PABLO NAT'L WILDLIFE REFUGE
MISSION MTNS. WILDERNESS
Ronan
NINEPIPE NAT'L WILDLIFE REFUGE
NAT'L BISON RANGE
Saint Ignatius
Ravalli
Arlee
Jocko River
Little Bitterroot River
CLARK FORK
SANDERS
MISSOULA
BOB MARSHALL WILDERNESS
LEWIS AND CLARK
POWELL
Missoula
FLATHEAD NATIONAL FOREST
OTHER NATIONAL FORESTS
UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
HUNGRY HORSE PROJECT
MONTANA
HUNGRY HORSE POWERPLANT
ENLARGEMENT AND REREGULATING RESERVOIR
LOCATION MAP
AUGUST 1980
447-100-59

ABBREVIATIONS USED IN THIS REPORT

BPA	Bonneville Power Administration
ft^3/s	cubic feet per second
FWS	U.S. Fish and Wildlife Service
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
MDFWP	Montana Department of Fish, Wildlife, and Parks
MW	megawatt
NEPA	National Environmental Policy Act
NPPC	Northwest Power Planning Council
PNUCC	Pacific Northwest Utilities Conference Committee
Reclamation	Bureau of Reclamation
WEES	Western Energy Expansion Study

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

MAPS

SUMMARY

In February 1977, the Bureau of Reclamation (Reclamation) completed a report on the Western Energy Expansion Study (WEES), which focused primarily on the hydropower opportunities for expanding the supply of electricity in the Western United States. The WEES was initiated partially in response to the growing need for electrical power but primarily because of dwindling oil and natural gas resources and the increasing cost of fossil fuels. One of the hydropower opportunities identified in the WEES was expansion of power facilities at existing Hungry Horse Dam and Powerplant in northwest Montana.

A preliminary study of the Hungry Horse potential was initiated in 1977 under authority of Federal Reclamation law (Act of June 17, 1902, 32 Stat. 388, and acts amendatory thereof and supplementary thereto). A report of the preliminary study findings, "Hungry Horse Powerplant Enlargement and Reregulating Reservoir Formulation Working Document," was completed in February 1981.

The preliminary study showed a favorable opportunity for increasing the power production (primarily peaking[1/]) at Hungry Horse. On this basis, a detailed planning study was initiated. However, recent load projections by Bonneville Power Administration (BPA) show that there is no need for peaking power in the immediate future, so new development is not warranted. Further, the most likely development--an uprate[2/] of the existing plant--is scheduled for accomplishment under the powerplant operation and maintenance program, with completion tentatively scheduled in fiscal year 1991.

The present detailed planning study was authorized by Congress on October 3, 1980, in Public Law 96-375 and was initiated in late 1981.

In view of the lack of need for additional peaking power, the Hungry Horse Powerplant Enlargement and Reregulating Reservoir study has been concluded. This report documents the study findings.

PRELIMINARY STUDY FINDINGS

Primary facilities of the Hungry Horse Project are Hungry Horse Dam, Reservoir, and Powerplant. The concrete arch dam has a crest length of 2,115 feet and a height of 564 feet. When full, the reservoir formed by the dam is 35 miles long, covers 23,800 surface acres, and contains 2,982,000 acre-feet in active storage. The powerplant contains four generators having a total nameplate rating of 285,000 kilowatts (kW) that are operated at a continuous overload of 328,000 kW when needed.

1/ Peaking power is that component of the total energy available that is used to meet daily load fluctuations.

2/ An uprate increases the generating capability of a unit by installing a new stator winding, upgrading various auxiliary equipment, and strengthening any mechanical limitations imposed by the turbine and generator system. In contrast, a rewind is simply a replacement of a deteriorated armature winding with no increase in capability beyond its original overload capacity if any.

The February 1981 preliminary study report discusses a 55-megawatt (MW) powerplant addition at the existing outlet works, a reregulating reservoir about 3.3 miles downstream, and expansion of the facilities at the existing Lid Creek recreation development on Hungry Horse Reservoir. Other alternatives or opportunities for power expansion outlined in less detail included (1) an uprate of the existing powerplant, (2) addition of a second powerplant on the left bank, and (3) a powerplant at the reregulating damsite.

Fishery enhancement and recreation opportunities included (1) addition of a multilevel outlet at the existing reservoir outlet, (2) replacement of old car bodies with riprap along the bank of the main stem Flathead River, (3) construction of a kokanee spawning channel downstream from the reregulating damsite, (4) modification of Hungry Horse Project operating criteria, (5) improvement of Hungry Horse visitor facilities, and (6) development of new recreation facilities (in addition to the Lid Creek expansion) along Hungry Horse Reservoir.

A major topic in the study was the effect that power expansion would have on the kokanee fishery of the upper Flathead River and Flathead Lake system. The study found that the power expansion potential appeared to be economically justified and that modification of power flows from Hungry Horse Dam could significantly improve the kokanee fishery of the upper Flathead River-Lake system. Also, power expansion appeared compatible with fish and wildlife and other interests, but additional detailed study would be necessary for assessment of the maximum acceptable power development.

FOCUS OF FEASIBILITY STUDY

As a result of favorable findings of the preliminary study, a detailed feasibility study was started. The focus of the feasibility study was directed at two concerns--power expansion and fishery enhancement. When the study was initiated, the power needs of the Pacific Northwest had been and were expected to continue to increase. At that time, a deficit, first in peaking capacity and then in average energy capacity, was expected to occur in the early 1990's. However, in recent years, the growth of power needs in the region slowed markedly, and present estimates indicate that there will be no need for additional peaking capability in the near future. Earlier studies had shown a potential for increase in both peaking and average energy production at Hungry Horse Powerplant, but later more detailed analysis showed that annual (average) generation is essentially maximized with the existing facility and that the development opportunity was limited to increasing the peaking capacity.

With the turnaround in future power demands, what had been the most promising expansion alternative (a new powerplant at the outlet works combined with an increase in the generating capacity of the existing units) was no longer needed. At this time, the evaluation of power expansion shifted from

an identification of the alternative with the maximum excess of benefits over costs[1] to identification of the most cost-effective alternative; i.e., the alternative with the least cost per kilowatt-hour (kWh).

The "least cost" analysis resulted in dropping the outlet powerplant from further consideration, and the study proceeded with evaluation of the potential for uprating the generating capacity of the existing power units. This type of increase is possible because under normal operating conditions the turbine (or hydraulic) capacity of the existing units substantially exceeds the generator capacity at normal operating heads. That is, a potential exists to significantly increase generating capacity of existing units by installing new, modern stator windings; upgrading various auxiliary equipment; and performing a mechanical analysis to determine any mechanical strengthening requirements.

A detailed evaluation during the designs and specifications stage will be needed to determine to what extent the generating capacity can actually be increased. Based on past performance tests, however, it appears that an increase of the nameplate rating of each unit from about 71 MW to 107 MW is realistic. An increase of this magnitude (an uprate) will also require an increase in the capacity of some of the auxiliary electrical equipment; however, most of this equipment is already scheduled for replacement to insure continued operation of the powerplant.

An uprate of the existing plant is not needed to meet present estimates of regional power needs over the next 20 years. However, the study continued with consideration of an uprate because the existing windings have already exceeded their 30-year expected useful lifespans (generators were installed in 1952 and 1953), and replacement is needed to assure continued operation of the generators. Reclamation operation and maintenance policy encourages increasing the generator electrical capacity at the time of unit rewinding if turbine capacity exceeds electrical capacity under normal operations and if such undertaking would be cost effective.

This policy of uprating at the time generating units need to be rewound is particularly applicable to the Hungry Horse Powerplant situation. Whenever additional peaking generation is needed, the system first looks at Hungry Horse Powerplant to meet that need; i.e., the location of the Hungry Horse Powerplant in the hydraulic system is favorable for peaking operations. As an example, Hungry Horse Powerplant, which is not normally used for peaking energy production in the summer, was used in the summer of 1985 for peaking energy production because of outage at another powerplant. Power need estimates have changed dramatically in the past 5 years from a definite need to meet future loads to very little or no need for increased generation to meet loads. Although the power estimates are the best that can be made, there

---

1/ The rules and regulations that Reclamation follows in water resource planning require that the first focus be on a plan that reasonably maximizes the Federal objective, which is a plan that provides the maximum monetary benefits after costs are subtracted. In addition, other plans, which may reduce this objective, may be formulated to further address Federal, State, local, and regional concerns not fully addressed by the plan that maximizes benefits.

is very little assurance that present estimates of future power needs can accurately predict needs over a period of more than 5 to 10 years. Differences in costs between an uprate and a rewind are minor since the major cost item, labor, is about the same for the two procedures and material costs are nearly equal. An uprate at a later date, after a rewind, would essentially duplicate the rewind procedure using heavier windings and would be inefficient and probably unacceptable; the small increase in power generation might not be able to pay for the costs of the uprate.

An uprate of the Hungry Horse Powerplant at this time appears to be a prudent action since costs of a rewind and an uprate are nearly the same and is low cost insurance in the event that peaking power needs will change in the future or will be needed on an emergency basis. The uprate, which will be accomplished through the project operation and maintenance program, is scheduled to begin in fiscal year 1986 and be completed in fiscal year 1991 (design activity in fiscal year 1986 and award contract in fiscal year 1987). Generators will be uprated in sequence over a 4-year period, with construction on only one generator at a time to maintain the powerplant in operation during the uprate. Since the generator under construction will be out of operation primarily during the normal annual operation and maintenance period when generation demands on the powerplant are normally low, no loss in generation is expected during the uprate period. Funds in the amount of $7.4 million have been budgeted for the operation and maintenance program to accomplish the uprate.

Another power option identified in detail is construction of a reregulating reservoir on the South Fork Flathead River about 3.3 miles downstream from Hungry Horse Dam. Operation of the reregulating reservoir would dampen flow fluctuation to allow an additional increase in peaking energy production without affecting downstream flows. Construction costs of $28,000,000, based on a January 1984 price level and interest during construction at 12-3/8 percent interest over a 3-year construction period ($5,488,000), would be reimbursable along with annual operation costs of $39,800. The annual financial requirement, based on a 50-year repayment period and an interest rate of 12-3/8 percent, would be $4,196,100. Peaking power would need to sell at about 65 mills per kilowatt-hour to repay the annual costs of the reregulating dam option. While this cost per kilowatt-hour is attractive, no need for additional peaking energy capability is estimated for the near future. As a result, this option was not pursued further. If, sometime in the future, an electrical power load-resource analysis for the Pacific Northwest should indicate a need for additional peaking capacity, the reregulating reservoir potential should be considered.

The other focus of the study was enhancement of the kokanee fishery, which has experienced a severely depressed population in recent years. During the last part of the preliminary study and the first part of the feasibility study, flows from Hungry Horse Dam were modified. These modifications were made in consultation with the Montana Department of Fish, Wildlife, and Parks (MDFWP) for study of flow effects on the kokanee fishery. As a result of these studies, MDFWP made certain recommendations on flows, and these recommendations were incorporated into the Northwest Power Planning Council's (NPPC) Fish and Wildlife Program. Kokanee fish populations have already shown some improvement with the flow modifications made during the study period. The present recommendations are designed to improve kokanee populations to

those levels experienced in 1975, before a decline in population became evident. Reclamation intends to continue to cooperate with MDFWP and the NPPC toward meeting recommended flows.

Meeting fish flows, uprating the powerplant, and a reregulating dam (if constructed) will have effects on generation at Hungry Horse Powerplant. To measure these effects, hydrology studies were made using a 39-year period of streamflow records. Table 1-1 shows average annual peak, nonpeak, and total generation expected with the following scenarios: (1) existing powerplant without meeting recommended fish flows, (2) existing powerplant meeting fish flows, (3) uprated powerplant (428 MW) meeting fish flows, and (4) uprated powerplant (428 MW) with reregulating reservoir meeting fish flows. Table 1-2 shows the power generation effects specifically attributable to (1) meeting fish flows, (2) an uprate, and (3) a reregulating reservoir.

Table 1-1.--Average Annual Generation with the Existing Powerplant, an Uprate to 428 MW, and a Reregulating Reservoir (kilowatt-hours)

Type of Generation	Without Fish Flows Existing Powerplant	With Fish Flows		
		Existing Powerplant	Uprate	Uprate plus Reregulating Reservoir
Peak[1/]	409,449,000	295,273,000	369,743,000	482,734,000
Nonpeak[2/]	540,451,000	651,027,000	578,857,000	453,366,000
Total	949,900,000	946,300,000	948,600,000	946,100,000

1/ Energy component generated to follow daily load fluctuations
2/ Total energy generated minus peak energy

Table 1-2.--Effects of Recommended Fish Flows, Uprate, and Reregulating Reservoir on Average Annual Generation (kilowatt-hours)

Type of Generation	Fish Flows[1/]	Uprate[2/]	Reregulating Reservoir[3/]
Peak[4/]	-114,176,000	+74,470,000	+112,991,000
Nonpeak[5/]	+110,576,000	-72,170,000	-115,491,000
Total	-3,600,000	+2,300,000	-3,500,000

1/ Energy generation of existing powerplant without meeting recommended fish flows minus energy generation while meeting fish flows
2/ Energy generation with uprate meeting fish flows minus energy generation with existing powerplant meeting fish flows
3/ Energy generation with uprate and reregulating reservoir while meeting fish flows minus energy generation with uprate meeting fish flows
4/ Energy component generated to follow daily load fluctuations
5/ Total energy generated minus peak energy

Total average energy generated is not significantly different (a maximum of 3,600,000 kWh) among any of the four scenarios; i.e., meeting fish flows, an uprate, and the reregulating reservoir have little effect on total average annual generation. Also, in all scenarios, a gain or loss in peak energy is offset by an approximately equal loss or gain in nonpeak generation. The effect of meeting fish flows is a loss of about 114,000,000 kWh peak energy generation per year. An uprate will recover about two-thirds of the peaking generation lost through meeting fish flows. If a reregulating dam is constructed, all of the annual peaking generation lost through meeting fish flows will be recovered and peaking generation will be increased by about 113,000,000 kWh over an uprate alone.

Even though power expansion alternatives are not needed at present, the conclusion of this study should not be interpreted to indicate that there will not be a future need for expansion of power at Hungry Horse or that such expansion will not be economically justified. Rather, expansion beyond the uprate is not justified considering near-term needs. Economic conditions, evaluation criteria, and needs may, in the future, change in such a way that power expansion may be desirable. Also, any future power development would recognize kokanee needs. If significant new peaking generation were proposed, a reregulating reservoir and other measures would likely be required to maintain conditions necessary for the fishery.

S E T T I N G

LOCATION AND PHYSIOGRAPHY

Hungry Horse Dam and Powerplant are located on the South Fork Flathead River at a location about 20 miles northeast of Kalispell and about 15 miles south of Glacier National Park in northwest Montana (see frontispiece map). The Flathead River basin lies along the west slope of the Continental Divide in the Rocky Mountain physiographic province. In the north, or upper, part of the basin are a series of northwest-trending mountain ranges with interfingered tributaries of the Flathead River. This basic form was initiated by a broad regional uplift combined with faulting about 60 to 70 million years ago and has remained essentially unchanged to the present.

Flathead Valley, in the western portion of the basin, is a part of the Rocky Mountain Trench, a large structural depression extending from northern British Columbia to the Missoula area south of the Flathead River basin. This valley was initiated by downfaulting and since has been partially filled with eroded material from nearby mountains and with glacial deposits. Outwash sediments from receding glaciers accumulated, and the Flathead River and its tributaries entrenched their courses about 100 feet into the consolidated valley-fill deposit. The river and its tributaries have continued to mature, creating broader flood plains and more gentle gradients.

Valleys of the North, South, and Middle Forks Flathead River are sharper in relief and lie between the northwest-trending mountains. The South Fork lies between the Flathead Range to the east and the Swan Range to the west in a valley that varies from 12 to 28 miles wide.

Large elevation differences within the Flathead basin provide a contrast between the mountains and Flathead Valley. Much of the Flathead Valley lies between 2900 and 3000 feet above mean sea level, while the elevation of some peaks in the drainage is over 10,000 feet. Elevation at the crest of Hungry Horse Dam is 3565 feet.

WATER RESOURCES

The Flathead River basin, the most northeasterly of the basins within the Columbia River system, covers approximately 8,830 square miles of area including 430 square miles located in Canada. Resources within the United States include 3,500 miles of streams, 450 lakes, and ground water. The dominant stream is the Flathead River, including the North, South, and Middle Forks, portions of which have been included into the National Wild and Scenic Rivers System. Other major streams include Whitefish, Stillwater, Swan, Little Bitterroot, and Jocko Rivers. Flathead Lake, one of the largest natural freshwater lakes found in the continental United States, is a dominant feature of the basin. The lake is partially controlled by Kerr Dam.

The North Fork Flathead River rises in the McDonald Range in Canada and flows southeasterly, forming the western boundary of Glacier National Park. About 40.7 miles of the North Fork from the Canadian border to Camas Creek is classified as a scenic river, and about 17.6 miles from Camas Creek to the confluence with the Middle Fork is classified as a recreational river.

The Middle Fork rises in mountains much farther south in Montana and flows northwest to its confluence with the North Fork, forming a portion of the southern boundary of Glacier National Park. From its headwaters to Bear Creek, about 46.6 miles, the Middle Fork is classified as a wild river. The remainder of the Middle Fork and the main stem Flathead River to the South Fork confluence (a total of about 54 miles) is classified as a recreational river.

The South Fork parallels the Middle Fork, emptying into the main stem Flathead River about 5 miles south of the Middle Fork confluence. The South Fork is classified as a wild river from its headwaters to the Spotted Bear River confluence (51.3 miles) and as a recreational river from Spotted Bear River to Hungry Horse Reservoir (8.8 miles).

The main stem Flathead River flows west from the South Fork confluence and then south to converge with the Whitefish and Stillwater Rivers to empty into Flathead Lake. South of the lake, the Flathead River flows generally south and then west to empty into the Clark Fork River. Water from the Flathead basin eventually reaches the Columbia River through the Clark Fork River and the Pend Oreille River which converges with the Columbia River just north of the Canadian border.

Slightly over 8.5 million acre-feet of water is discharged into the Clark Fork River from the Flathead River in an average year. This amounts to about 19 inches of depth over the watershed, a high amount for an inland western basin. Most of this discharge derives from above Flathead Lake; average annual flow of the Flathead River at Columbia Falls is 7.1 million acre-feet. Slightly more than one-third of the flow above Columbia Falls is contributed by the South Fork. The average annual runoff of the South Fork at Hungry Horse Dam is about 2.6 million acre-feet. Peak unregulated flows resulting from snowmelt runoff normally occur during the month of June. Natural minimum flows occur during mid-winter when precipitation accumulates as snowpack.

SOCIOECONOMIC CHARACTERISTICS

The economic development of Flathead County has been based primarily on manufacturing, forestry, and agriculture. In recent years, tourism has become important in the economy, and growth is expected to continue. County population has grown faster than the national or State growth rate during the past two decades. Most of the population increase since 1970 has been due to inmigration. Unemployment has been a persistent problem, and the county is listed as a labor surplus area by the U.S. Department of Labor.

Over 60 percent of the Montana portion of the Flathead basin is in public ownership, most of which is federally managed. The Flathead Indian Reservation, located in Lake and Sanders Counties, covers about one-fourth of the basin. The southern half of Flathead Lake, which is important to the Indian economy and values, is located on the reservation.

PRESENT DEVELOPMENT AND OPERATION OF HUNGRY HORSE PROJECT

The major water storage in the basin is provided by Flathead Lake and Hungry Horse Reservoir. Major power developments are Kerr Dam and Powerplant on Flathead Lake and Hungry Horse Dam and Powerplant on the South Fork Flathead River.

Authorized purposes of the Hungry Horse Project include irrigation, navigation, flood control, and hydropower generation. The dam and powerplant were completed in 1953.

Hungry Horse Dam is a concrete arch gravity structure with a crest length of 2,115 feet, a height of 564 feet, a crest width of 39 feet, and a base width of 330 feet. Hungry Horse Reservoir, the impoundment formed by the dam, is 35 miles long, covers 23,800 surface acres, and contains 2,982,000 acre-feet of water in active storage at normal full pool elevation of 3560. The powerplant contains four generators, with a total nameplate rating of 285,000 kW (71,250 kW each), that are operated at a continuous overload of 328,000 kW when needed.

Hydroelectric generation from the powerplant averages slightly less than 1 billion kWh annually and is marketed as part of the Federal Columbia River Power System by BPA. The principal power benefits of the project, however, come from the stored floodwaters which are released downstream during the fall and winter. In an average year, about 4.6 billion kWh of energy are generated from these releases as the water passes through 19 downstream powerplants.

Flood control operations at the Hungry Horse Project reduce flooding in the Flathead Valley. These operations also reduce flooding and peak flows farther downstream by 10 to 25 percent. Watercourses affected include the Clark Fork River in Montana and Idaho, the Pend Oreille River in northern Idaho and Washington, and the Columbia River from the confluence with the Pend Oreille River in Canada to Grand Coulee Dam in north-central Washington.

Hungry Horse is a cyclic storage project; the reservoir has more storage capacity than the total of the average annual inflow. The reservoir could be drafted over a series of years (the number of years depending on inflow) before reaching a minimum conservation level. Average annual drawdown is 72 feet to elevation 3488 feet, and maximum drawdown is about 130 feet; full pool elevation of 3560 feet is achieved in most years. Drafting begins in the fall and continues throughout the winter to provide electric power and space for flood control. Spring releases, based on anticipated runoff, are made to provide flood control and to allow the reservoir to refill by July. From July through September, an attempt is made to maintain a full reservoir, pool

elevation of 3560 feet, for recreation. The cycle is then repeated beginning in October. Essentially all of the releases are through the powerplant, and water is seldom spilled downstream through the spillway or outlet works.

While the annual drafting and filling cycle of the reservoir follows a regular pattern, monthly, weekly, and daily discharges from the powerplant are irregular. Decisions related to hourly and daily operation are made by the BPA control center in Vancouver, Washington. Requests for power vary with weather conditions, outages at other plants, and other factors. As a result, the powerplant may be shut down or in partial or full operation for hours or several consecutive days. One or two generators may be operated continuously for longer periods to serve baseload needs. Discharge from the powerplant (South Fork flows below the plant) has varied from a minimum of 145 cubic feet per second (ft^3/s) to about 11,420 ft^3/s, but variations are generally less. Greatest flow variations normally occur during winter months when peakloads are met. Since 1982, releases from Hungry Horse Dam have recognized streamflow recommendations (to improve the main stem Flathead River kokanee fishery) under the NPPC's Fish and Wildlife Program.

Under normal reservoir operation, the hydraulic head on the generators ranges from 264 to 488 feet at full pool level. Rated head of the generators is about 400 feet, and hydraulic capacity of the turbines and penstocks is 11,420 ft^3/s at this head. Although hydraulic capacity increases at heads above 400 feet, the additional capacity cannot be used because the electrical limits of the generators would be exceeded. At a hydraulic head of less than 400 feet, hydraulic capacity, powerplant efficiency, and power generating capability decrease.

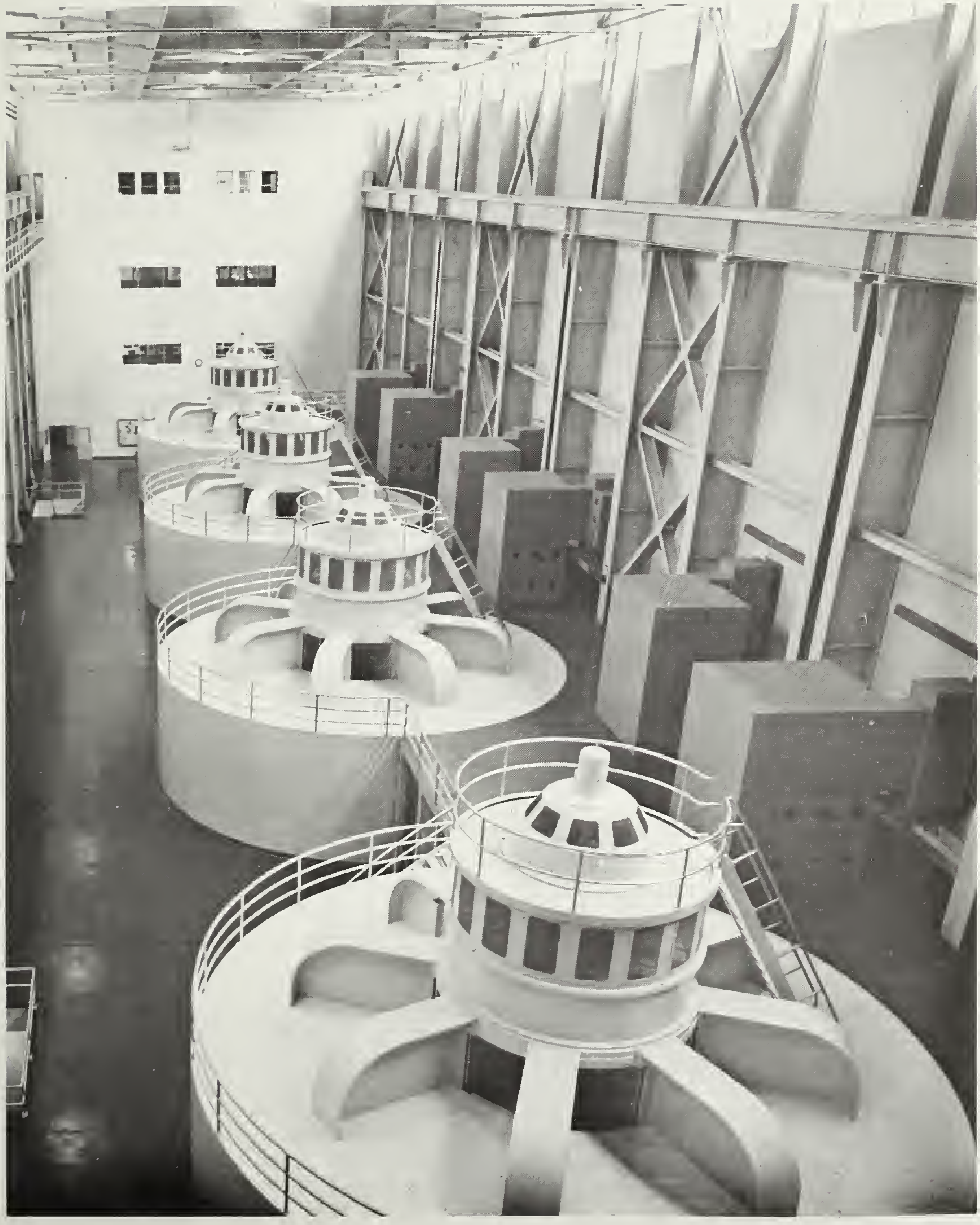
FISHERY

The fishery of the Flathead Lake-Flathead River system is nationally renowned and depends entirely on natural production. The main stem Flathead River, from the confluence of the Middle and North Forks to the mouth of the Stillwater River (33 miles), is one of the thirteen streams that the State of Montana classifies as a blue ribbon fishery.

This fishery, which consists of natural and introduced species, is dependent upon the entire Flathead River-Lake system, which functions as a complete ecological unit. For many of the important game fish populations, the river and tributaries provide necessary spawning and juvenile development areas, while the lake provides a more abundant source of food for faster adult growth and development. Without the tributaries or access to them through the main rivers, the lake populations would diminish, and without the lake, there would be fewer fish in the tributaries.

Hungry Horse Dam and Reservoir (P447-100-236)

Visitor Center and parking area (foreground), powerplant, and switchyard (toe of dam) at the Hungry Horse Project. Also partially visible are the glory hole overflow spillway (round structure on left) and log boom which acts as a safety barrier to boaters and limits collection of floating debris along the dam. (P447-100-159)



Hungry Horse Powerplant contains four equal-sized generators having a total nameplate rating of 285,000 kilowatts. (P447-100-207)

Of the 24 species living in the lake, only 10 are considered native to the drainage, and these species make up a relatively small portion of the game fish population. Indigenous game species of importance are westslope cutthroat trout, bull trout,[1/] and mountain whitefish. Introduced species include brook trout, rainbow trout, lake trout, and kokanee salmon. Other game fish include yellow perch, largemouth bass, and northern pike. Nongame fish include squawfish, peamouth, and suckers.

Three patterns of fish movement have been identified according to migratory habits of the fish: (1) stream/lake pattern (2) small/large stream pattern, and (3) limited stream movement pattern. Most bull trout, cutthroat trout, kokanee salmon, and some mountain whitefish have a stream/lake movement pattern. These fish live their adult lives in the lake and migrate into the inflowing streams to spawn. After hatching, bull trout and cutthroat trout live in the river and its tributaries for about 2 years and then migrate to the lake. Cutthroat trout may make two spawning runs during their average lifespan of 6 years. Kokanee salmon young migrate downstream soon after hatching and become adults in 2 to 4 years. Kokanee salmon are a landlocked form of the Pacific sockeye salmon and die soon after spawning.

Some races[2/] of bull trout and westslope cutthroat trout and most mountain whitefish show a small/large stream movement pattern, living their adult lives in the larger streams and spawning in the smaller streams. Some westslope cutthroat trout and mountain whitefish show a limited movement pattern, living their entire life cycles in small segments of a stream. The migratory behavior of various fish species present in the Flathead Lake-Flathead River system is shown below.

Species	Lake/Stream Races	Small/Large Stream Races	Limited Movement Races
Bull trout	Yes	Possible	Yes
Westslope cutthroat trout	Yes	Yes	Yes
Mountain whitefish	Yes	Yes	Yes
Brook trout	Limited	Yes	Yes
Kokanee salmon	Yes	No	No
Rainbow trout	No	No	Yes
Lake trout	No	No	No

Kokanee salmon are the most popular game fish in the Flathead basin, amounting to about 90 percent of the total fish harvested in the 1981-82 fishing season. These fish normally spend 4 years in Flathead Lake before reaching spawning readiness in the fall, at which time they enter the Flathead River and tributaries to spawn and then die. Adults are present in the river from late September to mid-December. Eggs incubate in spawning bed gravels, hatching by mid-April. After hatching, the yolksac is absorbed and the fry rapidly migrate downstream to begin a 4-year period in the lake.

1/ Bull trout is the inland form of Dolly Varden, a costal anadromous fish.
2/ A race is a population within a species that differs in one or more inherent characteristics from other populations of that species.

The main stem Flathead River is a corridor for fish migrating from the lake to upstream spawning areas. Lake/stream migrant races of cutthroat trout move as far as 80 miles upstream, and bull trout travel as far as 120 miles to reach spawning beds in the Middle Fork and North Fork Flathead Rivers. Kokanee salmon spawn in the main stem or pass through the main stem to tributary spawning beds. One of the more important spawning streams is McDonald Creek, which is located in Glacier National Park and enters the Middle Fork Flathead River just above the confluence of the North and Middle Forks. More than 300 bald eagles and several grizzly bears are often drawn to McDonald Creek to feed on kokanee during the fall spawning run.

Fish habitat in the South Fork Flathead River below Hungry Horse Dam is limited. However, kokanee spawning in the reach has been increasing in recent years. Few trout and mountain whitefish are present in this reach.

WILDLIFE

Wildlife of the basin is diverse. Significant species found in the river valleys include white-tailed deer, ruffed grouse, river otter, beaver, muskrat, mink, raccoon, and black bear. In addition, there are various shore birds, songbirds, and migratory waterfowl. Bald eagles migrate through the area, and some winter in the basin.

Animals present in the mountains include white-tailed deer, mule deer, black bear, grizzly bear, gray wolf (northern Rocky Mountain wolf), moose, elk, bighorn sheep, mountain goat, fisher, marten, mountain lion, lynx, ruffed and spruce grouse, and numerous small birds and mammals.

The area just below Hungry Horse Dam provides marginal habitat for white-tailed deer, ruffed grouse, songbirds, rodents, otter, mink, black bear, and possibly an occasional grizzly bear.

ENDANGERED AND THREATENED SPECIES

Several species included on the United States list of endangered and threatened species occur in the upper Flathead River basin. These species include the gray wolf, peregrine falcon, and bald eagle which are listed as endangered and the grizzly bear which is listed as threatened.

The gray wolf is found in limited numbers in the basin. The grizzly bear ranges over much of the basin and has been sporadically observed along the South Fork Flathead River. Bald eagles winter in the basin and feed on fish in the South Fork. At present, there is no evidence of eagle nesting along the South Fork. Peregrine falcons probably pass through the basin during migration.

PROBLEMS AND NEEDS

ELECTRIC POWER

The Hungry Horse Powerplant Enlargement and Reregulating Reservoir study was initiated because of an apparent need for additional electric power generating capability in the near future. In addition, the United States was highly dependent on importation of energy sources for generation of electricity, and that dependence appeared to be increasing at an alarming rate. In 1981, when the preliminary study report was completed, the electrical energy picture in the Pacific Northwest had not changed.

The Pacific Northwest, as a unit, was used as the study area for determining power needs. This was done for several reasons. Most of the larger power generating facilities are located at considerable distances from population or use centers and are tied together by a transmission network. The separation of generating and load areas means that most local areas or river basins are either net importers or net exporters of electric power. Also, the Pacific Northwest is unique in that approximately 80-85 percent of the electrical power consumed in the region is generated by hydroelectric plants. Federal, non-Federal public, and private generation facilities operate on the same rivers and streams and use the same transmission facilities. In essence, the Pacific Northwest power generating facilities are both hydraulically and electrically tied into one system, which is operated as a unit. To achieve efficiency in generation and transmission of power requires a great deal of coordination among various utilities and with storage located in Canada.

In 1980, the power forecasts for the region were made by the Pacific Northwest Utilities Conference Committee (PNUCC), a planning forum made up of utilities and power agencies in the region. The 1980 analysis indicated that although both system load and generating capability were expected to increase, a net deficit in both peaking and average generating capability were projected to occur in all years from 1980 through 1999. Since projected generating capability was based on critical water conditions (minimum streamflows), generating capability greater than the projections would be available only during periods of greater streamflow. To account for the variability in streamflows, the analysis included probability projections of not meeting energy loads. These projections showed that the probability of not meeting total energy loads would vary from 36 to 79 percent in each of the years 1981 through 1991. There was a 99-percent chance of curtailment of firm energy[1/] loads in at least 1 year between 1980 and 1991. Unlike previous short-term curtailments of hours or a few days, future curtailments were expected to be more lengthy, extending over months or years.

1/ Firm energy is that component of the total energy intended to have assured availability.

BPA, which markets the power produced at Federal (Bureau of Reclamation and Corps of Engineers) hydroelectric powerplants in the Pacific Northwest, informed its customers of the impending deficit of power. BPA also notified its preference customers that it would not have enough power to meet their growth requirements after June 30, 1983. In addition, BPA notified its direct service industrial customers that it would not be able to renew their contracts when they expired, mostly in the mid-1980's.

Since 1980, a series of events have occurred which have completely changed the electrical power picture in the Pacific Northwest. In 1980, the Pacific Northwest Electric Power Planning and Conservation Act was passed. The act authorized BPA to acquire the energy resources it needs to fulfill its obligation to deliver a dependable power supply from the Federal Columbia River Power System to its customers. The act also established the Northwest Power Planning Council, made up of two members from each of the four northwestern states.

Based upon concepts set forth by the NPPC, BPA has developed its current energy resource strategy. Under the 1980 act, conservation is a priority source for making energy available to meet new demands. Since conservation programs are voluntary, the amount of future energy savings from conservation measures is somewhat uncertain.

However, since 1980, conservation efforts and depressed economic conditions in industrial and manufacturing sectors have substantially reduced energy use. Recent BPA analyses of power needs in the region indicate that power supplies will exceed power demands for several years. These analyses use a conservative estimate of energy availability, being based on critical water years (years when water supplies are at a minimum); in most years energy production would be greater than that used in the projections. The duration of the current power surplus is, however, uncertain. Under BPA's 1984 high growth load forecast, new power resources could be needed as soon as 1989. If low growth in loads occurs, the surplus may extend past the year 2000. These forecasts are for average energy.

The large difference in needs between BPA's high and low growth forecasts reflects the uncertainty of projecting power surpluses or deficits. The present forecasts involve many assumptions concerning large industrial users and nuclear powerplants. If one or a few assumptions do not hold true, a rapid revision in the energy picture for the Pacific Northwest would be necessary.

FISHERIES

Power generation at Hungry Horse Dam directly affects streamflows in the main stem Flathead River from the confluence of the South Fork to Flathead Lake; the Flathead above the South Fork confluence is unregulated. This reach is a corridor in which many kokanee spawn and through which other fish must migrate to reach upstream spawning areas. Kokanee productivity in the main stem and South Fork Flathead River is affected by the extreme flow fluctuation and irregular flow patterns caused by releases from Hungry Horse Dam. In the past, the project has been operated to meet authorized project purposes of power generation and flood control, and these operations have affected fish

productivity. Irregular flows confuse fish, alter feeding conditions, and decrease the production of aquatic insects, which are the primary food supply for fish.

A major concern has been that high flows during the kokanee spawning period induce fish to form redds (nests) at higher elevations on the streambed. During low flow periods, which may last several days, the eggs and developing embryos in these redds would be exposed to the air and freeze or dry. Eggs and embryos may be destroyed in less than 30 hours when low flows occur during periods of very low air temperatures.

Because of these concerns, Reclamation, between 1979 and 1982, contracted with the MDFWP to inventory the fish and aquatic insect populations of the Flathead River system. The contract also included provisions to develop flow recommendations to maintain or improve the fishery under future project conditions. The Environmental Protection Agency and BPA have funded related studies since 1982.

As a part of the contract studies, flows from Hungry Horse Dam were modified, particularly during the kokanee spawning season (fall) and during the winter, to see what the effects would be on the fishery. In general, the modifications consisted of reducing flows (compared to historic levels) during the spawning season and increasing flows above historic levels during the winter. The effect of this was to cause kokanee to form redds lower on the riverbed profile where winter flows could cover the redds and protect the incubating eggs from freezing. Kokanee egg survival with these flow regimes were improved over that in the recent past. The MDFWP was able to develop flow recommendations to provide for an optimum number and size of kokanee in the Flathead River-Lake system. Their recommendations do not maximize the number of kokanee because as kokanee numbers increase the size of the fish decrease, a result of density-dependent relationships of food production in Flathead Lake. The optimum condition was defined as a balanced number of spawning-aged fish approximately 13 inches in length. A management objective of the MDFWP is a main stem Flathead River preharvest kokanee run of 330,000 spawners.

MDFWP's recommended flows are concurred in by the U.S. Fish and Wildlife Service (FWS) and have been adopted by the NPPC in its Fish and Wildlife Program. A Fish and Wildlife Coordination Act report has been completed by the FWS and also includes these flows. These recommended flows are instantaneous flows at Columbia Falls, which is just downstream from the South Fork confluence with the main stem Flathead River. Hungry Horse operations, however, cannot guarantee meeting these flows at all times because two-thirds of the flow in the main stem is from the unregulated portion of the system above the confluence of the South Fork. MDFWP estimates that 165,000 kokanee spawners averaging about 12.8 inches in length would be available for river harvest if these flows are followed. This approximates optimum conditions for the kokanee fishery and represents a major improvement and return to fishery levels experienced before the kokanee fishery decline in the mid 1970's. In November 1985, MDFWP recommended to the NPPC to continue the fish flows with a slight modification; flushing flows in the spring are no longer recommended. The present recommended flows are shown in table 3-1.

Table 3-1.--Recommended Flows at Columbia Falls

Time Period	Flows in Cubic Feet Per Second	
	Minimum	Maximum
October 16-December 15	3,500	4,500
December 16-October 15	3,500	None specified

Establishment of the recommended minimum flows is also needed for other migratory and resident fish that use the reach of the main stem from the South Fork confluence to Flathead Lake. The flow constraints would improve invertebrate food production and would provide protection for overwintering and rearing fish.

It should be recognized that the flows at Columbia Falls and downstream are influenced by the unregulated North and Middle Forks of the Flathead River as well as the South Fork which is regulated by Hungry Horse Dam. Because of the unregulated inflow, it will not be possible in every year to precisely meet flow recommendations at Columbia Falls through Hungry Horse operation. In years of high runoff, discharge from the Middle and North Forks may by itself exceed the 4,500-ft^3/s limitation for the spawning season. Conversely, in consecutive years of low runoff, Hungry Horse may not have adequate storage to compensate for North Fork and Middle Fork deficiencies.

Reclamation has provided the recommended flows since 1982 and is committed to providing the recommended flows through November 1985 to enable MDFWP to continue its study of kokanee spawning in the main stem Flathead River. Reclamation intends to continue to cooperate with MDWFP and the NPPC toward meeting recommended flows. Meeting the flow recommendation, however, does involve power losses (see table 3-2). Peaking generation is curtailed during the spawning season to meet the recommended flow maximums, and some loss in peaking during the winter may be experienced as a result of meeting winter flow minimums. Overall, there is a minor loss in total annual generation; loss in peaking generation is significant and accompanied by a gain in nonpeak generation.

Table 3-2.--Average Annual Power Losses Associated with Meeting Recommended Streamflows at Columbia Falls (Existing Powerplant)

Type of Generation	Amount (Kilowatt-hours)		
	Without Recommended Flows	With Recommended Flows	Difference
Peak 1/	409,449,000	295,273,000	-114,176,000
Nonpeak 2/	540,451,000	651,027,000	+110,576,000
Total	949,900,000	946,300,000	-3,600,000

1/ Component of total energy generation used to meet daily load fluctuations
2/ Total energy generated minus minus peaking energy

The peaking energy losses shown in table 3-2 could be partially recovered by an uprate of the powerplant to 428 MW and more than offset by construction and operation of a reregulating dam downstream from Hungry Horse Dam. These potentials are discussed in the "Plan Elements" chapter.

OTHER PROBLEMS AND NEEDS

A variety of other problems, needs, and development opportunities were identified in the 1981 report on the preliminary study. These included recreation facility additions and visitor center improvements at Hungry Horse Project; new irrigation; municipal and industrial water supplies; flooding; and air, land, and water quality. It was concluded at that time that none of these functions except for recreation would be addressed in the present study. The primary reason for that decision was that solution of the problems did not require a Federal effort or that public support of a Federal effort was lacking.

Additional identification and evaluation of recreation needs at the Hungry Horse Project were made. Although there is an excess of campsites located along Hungry Horse Reservoir, there is a problem in the distribution or location of those sites. More camping sites are needed close to Hungry Horse Dam, and fewer sites are needed located at a distance from the dam.

FORMULATION OF PLANS

The preliminary study (February 1981 Formulation Working Document) identified a plan that included power, recreation, and fishery functions. This outlet power plan included a new 55-MW powerplant at the existing outlet works, a reregulating dam and reservoir about 3.3 miles downstream from Hungry Horse Dam, and expansion of the existing Lid Creek Campground on the west shore of Hungry Horse Reservoir. In addition to these potentials, several alternative power potentials, other recreation facilities, and fishery improvement measures were identified. This section identifies those potentials and explains which potentials were dropped from further consideration during the formulation process.

PRELIMINARY STUDY

The following power alternatives were identified: (1) outlet powerplant; (2) uprate of the existing generators (to more than 15 percent capability above present nameplate rating); (3) a new 100,000- or 200,000-kW powerplant to be located on the left bank of Hungry Horse Dam; and (4) a 4,000-, 6,000-, or 8,000-kW low head powerplant to be located at the reregulating dam. At the conclusion of the preliminary study, a powerplant at the reregulating dam appeared not to be economically justified.

Recreation elements identified were (1) expansion of the Lid Creek Campground, (2) construction of new recreation facilities along Hungry Horse Reservoir, and (3) modernization and expansion of the existing visitor facilities at Hungry Horse Dam.

Other elements included (1) a reregulating dam and reservoir downstream from Hungry Horse Dam to increase peaking capability, to meet fishery flows, or both; (2) construction of a multilevel outlet works at Hungry Horse Dam to improve the temperature regime in the main stem; (3) modification of Hungry Horse operating criteria to meet fishery flows; (4) construction of a kokanee spawning channel just below the reregulating dam to compensate for loss of feeding habitat for bald eagles caused by reregulating reservoir operation; and (5) removal of old car bodies now located along the main stem Flathead River and replacement with riprap to improve appearance and fishery habitat. At the conclusion of the preliminary study, the multilevel outlet works did not appear to be justified from the standpoint of capability to meet the need or the potential loss of reservoir fishery compared with benefits to the downstream fishery.

POWER CONSIDERATION

As recently as 1980, power demand forecasts for the region indicated a need for additional peak power generating capability (see "Problems and Needs"). Since 1982, however, conservation efforts, in general, and reduced

energy use in the industrial and manufacturing sector, as a result of economic conditions, have delayed the need for added peaking capability beyond the timeframe of current forecasts. This rapid change in forecasts highlights the difficulty in estimating future power needs and the potential for forecast changes in the future.

About midway through the feasibility study, it became apparent that none of the power alternatives were needed--a result of the complete turnaround in the Pacific Northwest's need for peaking capability. With this change, the outlet powerplant was dropped from further consideration. The study then focused on increasing the capacity of the existing four generating units, which would have a much lower cost per kilowatt-hour of increased power production than any other alternative. Although only a detailed evaluation during the design and specification stage can determine how much the generating capability can actually be increased, the hydraulic capacity of the generating units does exceed the electrical capacity. Based on past performance tests, it appears that increasing the nameplate rating of each unit from 71.25 MW to 107 MW (a total increase of 143 MW above present nameplate rating and 100 MW above the existing continuous overload capacity) is a reasonable expectation.

Replacement of the generator windings is needed in the near future because their estimated useful lifespans of 30 years have already been exceeded; the generators were installed during 1952 and 1953. Replacement of windings is normally done through the project operation, maintenance, and replacement procedures and is made to assure continued operation of the powerplant.

Reclamation operation and maintenance policy encourages the investigation and implementation of all viable opportunities to improve existing plants by modernizing and uprating the generating equipment at the time units are scheduled for rewind. A good indicator for considering uprating a generator exists if the turbine capability substantially exceeds the generator capability at normal operating heads. This is true of the units at Hungry Horse. Modern developments in insulation technology provide the capability of manufacturing windings with increased electrical capacity but of the same physical size as earlier manufactured windings. It appears possible to increase the capacity of the Hungry Horse units by installing new, modern stator windings and upgrading various auxiliary equipment. Performing a mechanical analysis to determine any mechanical strengthening requirements would be included in the procedure.

Major factors in considering an uprate as an alternative to a rewind include (1) an uprate or a rewind is needed to assure continued operation of the powerplant, (2) the major portion of the cost of an uprate or rewind is associated with labor which would be nearly the same with either procedure, (3) the difference in cost of materials between an uprate and a rewind would be minor, (4) projections of future energy deficits and surpluses have been less than reliable in the past, (5) Hungry Horse Powerplant is located high in the hydraulic system and can be the first powerplant considered when additional peaking energy is required (to meet normal loads or in emergencies due to other powerplant outages), and (6) an uprate following a recent rewind would duplicate costs which probably could not be justified.

With continued economic growth of the region, additional peaking power will eventually be needed. If there is a possibility that additional peaking capacity will be needed in the system anytime in the next 30 years because of load growth or during unexpected outages of other powerplants, an uprate of the Hungry Horse units at the time of normal maintenance rewinding appears to be a prudent action. A decision has been made to proceed with the uprate. The present schedule for uprating the powerplant is:

1. Fiscal year 1986--designs and specifications for an uprate will be started by the Denver Engineering and Research Center

2. Fiscal year 1987--designs and specifications completed and contract advertised and awarded

3. Fiscal year 1988--uprate construction activities initiated

4. Fiscal year 1991--completion of construction activities

This schedule is subject to appropriate congressional action to provide the necessary funding. The uprate is further discussed in the "Plan Elements" chapter.

As explained in the next section, Reclamation will cooperate with the NPPC and MDFWP to help meet recommended flows in future operations, whether or not additional facilities are constructed. Because flows would likely be met in the future with or without additional facilities, a reregulating reservoir can be viewed as a power element. That is, downstream flows would not be significantly changed with the reregulating reservoir, but peaking capacity increases would be possible. Since additional peaking power is not needed at present or in the near future and unlike the uprate the reregulating reservoir is not an alternative to a rewind, the reregulating reservoir was dropped from further consideration at this time. The reregulating reservoir may be an attractive option at such time as additional peaking capability is needed. The reregulating reservoir option is discussed in the "Plan Elements" chapter.

FISHERY CONSIDERATIONS

At the beginning of the preliminary study, Reclamation realized that a key factor in the study and for any potential power addition was the effect of Hungry Horse operations on the fishery, especially the kokanee fishery. During the late 1970's, the kokanee spawning run in the main stem Flathead River rapidly declined. This decline appears to be related to changes in the operation of Hungry Horse Dam. Seasonal operations shifted to higher flows during the spawning period in the fall, and these flows were followed by periods of lower flows during the winter egg incubation period. This operational pattern led to dewatering and freezing of incubating kokanee eggs deposited during the spawning season when flows were at higher levels. The number of postharvest spawners fell from about 150,000 in 1975 to fewer than 10,000 in 1979. MDFWP established a management goal of about 165,000 escaping spawners for the main stem Flathead River. This goal is based on producing a run similar to that experienced in 1975, which was considered a good year for kokanee production.

Since 1979, Reclamation has worked with MDFWP to define a program for conservation and enhancement of the Flathead River fishery and has funded studies until 1982. The study process, research, and controlled test flows have contributed greatly to the understanding of the fishery and to development of a recommended streamflow program. MDFWP has continued studies with funding provided by BPA.

The studies concentrated on the reach of the Flathead River from Columbia Falls to Flathead Lake because this is the spawning reach that is influenced by Hungry Horse operations. Flows in this reach are influenced by the unregulated North and Middle Forks and by the regulated South Fork. Although kokanee have historically traveled through this reach to spawn in great numbers at McDonald Creek, a large percentage of the spawning occurs below Columbia Falls. Findings of the studies confirmed that the flow patterns during spawning and later during incubation periods in this reach were critical to the kokanee productivity. The studies also indicated that high flows during the kokanee spawning period resulted in redds placed high on the streambed profile, and these redds could be left high and dry during some part of the winter; developing embryos would be killed. Controlled flow tests confirmed that egg losses would be decreased and fry survival increased if flows during the spawning period could be limited to a level that would be maintained or exceeded during the incubation period. A bibliography of the literature produced by the studies of the kokanee fishery is provided in the Addendum.

Recommended flows were developed by MDFWP, and these flows were adopted in the NPPC's Fish and Wildlife Program. The recommended flows are shown in the "Problems and Needs" chapter.

Flow recommendations cannot be precisely met in every year through operations of Hungry Horse because the North and Middle Forks are unregulated. In years of high runoff, discharge from the North and Middle Forks alone may exceed the 4,500-ft^3/s limitation during the spawning season. Conversely, in consecutive years of low runoff, Hungry Horse may not have adequate storage to provide minimum flows in the fall and winter to compensate for low North Fork and Middle Fork runoff.

During the formulation process, two means of possibly meeting the recommended flows were identified. One means was to modify Hungry Horse operations to attempt to meet the flows. This would mean a loss in peaking power generation, especially during the kokanee spawning season. The other means was to construct a reregulating reservoir downstream to modify power flows so that peaking losses could be minimized. A reregulating dam would block access to kokanee spawning areas above the damsite, which in turn would adversely affect bald eagle feeding along the South Fork. But, a reregulating dam would enable operations to regain peaking capability otherwise lost through meeting recommended streamflows.

As mentioned in the previous section, Reclamation is committed to meeting the recommended flows through 1985. Present project operations meet the recommended flows through modification of Hungry Horse operation with a consequent loss in peaking power generation. Reclamation intends to continue to cooperate with MDFWP and the NPPC toward meeting recommended flows.

WILDLIFE CONSIDERATIONS

With present operations, bald eagles nest and roost in the vicinity of the reregulating reservoir site and feed on kokanee and whitefish that spawn in the gravels at the site. Fishery studies by MDFWP indicate that 500 to 7,500 kokanee spawners annually used the South Fork below Hungry Horse Dam during the period 1981 to 1984. A reregulating reservoir constructed at the site would deprive the endangered bald eagles of a food source since kokanee access to the area would be permanently blocked by the reregulating dam. A fishery could not be sustained within the reregulating pool because of severe water fluctuations.

Surveys of the bald eagle and other wildlife populations along the South Fork were made to determine the actual numbers and the possible effects of construction and operation of a reregulating dam. As many as 33 bald eagles have been observed along the reregulating reservoir site when eagles congregate in the fall to feed on spawning kokanee. Studies indicate that the bald eagle food supply at the site would be eliminated by construction of a reregulating reservoir and that some type of mitigation measure would be necessary. A Fish and Wildlife Coordination Act report was completed by the FWS. Although bald eagles congregate in the area to feed, there is no evidence that bald eagles nest (reproduce) in the area. The only mitigation identified was construction of a kokanee spawning channel on the left bank below the reregulating reservoir damsite.

Another consideration during formulation was the possible interference of the reregulating reservoir with movement of big game animals. Wildlife observations made during the study indicate that big game use in the area of the reregulating pool appears to be local with limited movement across the North Fork. Construction and operation of a reregulating reservoir would not have a significant effect on big game movement.

Species of threatened and endangered wildlife (in addition to bald eagles) that are possible residents or may rarely use the area are grizzly bear, gray wolf, and peregrine falcon. A reregulating reservoir would not be expected to have any effect on these species.

In contrast to a reregulating dam and reservoir, modifying Hungry Horse operations to meet downstream flow recommendations would not be a significant change and would not have a significant effect on the bald eagle population or other wildlife.

OTHER CONSIDERATIONS

A variety of other considerations were not addressed beyond the analysis made during the preliminary study. In general, additional analysis was not needed and not initiated after analysis of power options indicated that the feasibility study should be concluded.

Additional analysis of recreation problems was completed before a decision was made to conclude the investigation. That recreation analysis showed that there is a need for additional campsites within 5 miles of Hungry Horse Dam. This area serves as an overflow for campers that cannot find space in Glacier National Park. Development of additional campsites at the existing Lid Creek Campground would help meet the need and should be considered if additional power development at Hungry Horse Powerplant is considered sometime in the future.

PLAN ELEMENTS

This section presents cost and benefit information on those plan elements still under consideration for a power function at the time a decision was made to conclude the study. Since Reclamation intends to continue to cooperate with MDFWP and the NPPC toward meeting recommended fishery flows, whether any additional facilities are or are not built, there are no plan elements specific to a fishery function. Also, since a plan for congressional consideration is not being recommended and recreation need was not the primary purpose for initiating the investigation, recreation elements are not included in this discussion. Recreation plan elements would be considered in any future investigation. Power is the only function included in this chapter.

The power elements considered in detail are (1) an uprate of the existing powerplant and (2) a reregulating reservoir.

Planning and construction of transmission lines to handle increased power generation are the responsibility of BPA. Before it was decided to conclude the study and limit the increase in new generating capability to an uprate of the existing plant, BPA had identified alternatives for handling the increased power generation at the site. The preferred alternative, at that time, appeared to be rebuilding the existing Hungry Horse-Columbia Falls 115-kilovolt (kV) line to a double-circuit 230-kV line. Transmission facility needs associated with the planned uprate will need to be reviewed with BPA. Use of the existing transmission system may now be the preferred plan for this action.

UPRATE

Facilities

The uprate plan consists of increasing the electrical capacity of the existing power units to a value determined by a comprehensive static, dynamic, and transient mechanical analysis of the turbine-generator system. Each of the existing four generating units would be uprated from the present nameplate rating of 71.25 MW to an estimated output of 107 MW at a maximum hydraulic head of 484 feet. Although the existing excitation equipment appears capable of handling the increased capacity, all the regulator and excitation equipment would be replaced to insure continued operation. A new 75-megavolt ampere phase shifting transformer to control the loading of the 115-kV system from the powerplant would be provided. Neutral grounding and current transformers would be replaced, and some minor metering equipment would be added. Existing circuit breakers and generator voltage bus are adequate for the uprate and would not be replaced.

Accomplishments

Table 5-1 shows the change in energy production associated with the uprate. The uprate would provide an average annual increase in peaking power production of about 74 million kWh, an increase in peaking production of about

33 percent. Average annual generation would remain relatively unchanged at about 948 million kWh. These estimates are based on operations that would meet present recommended streamflows at Columbia Falls.

Table 5-1.--Average Annual Power Production with an Uprate to 428 MW

Type of Generation	Amount (kWh) Existing Powerplant	Uprate	Difference
Peak 1/	295,273,000	369,743,000	+74,470,000
Nonpeak 2/	651,027,000	578,857,000	-72,170,000
Total	946,300,000	948,600,000	+2,300,000

1/ Energy component generated to follow daily load fluctuations
2/ Total energy generation minus energy for peaking

Construction

Actual construction will extend over a 4-year period and will be staged. One generator each year will be under construction, primarily during the powerplant's regular maintenance period in the spring. Since the operation at this time of year is to fill the reservoir and generation is normally low or minimal, the three generators not under construction should be capable of handling any load requirement. Total annual generation of Hungry Horse is not expected to be significantly affected during the construction period.

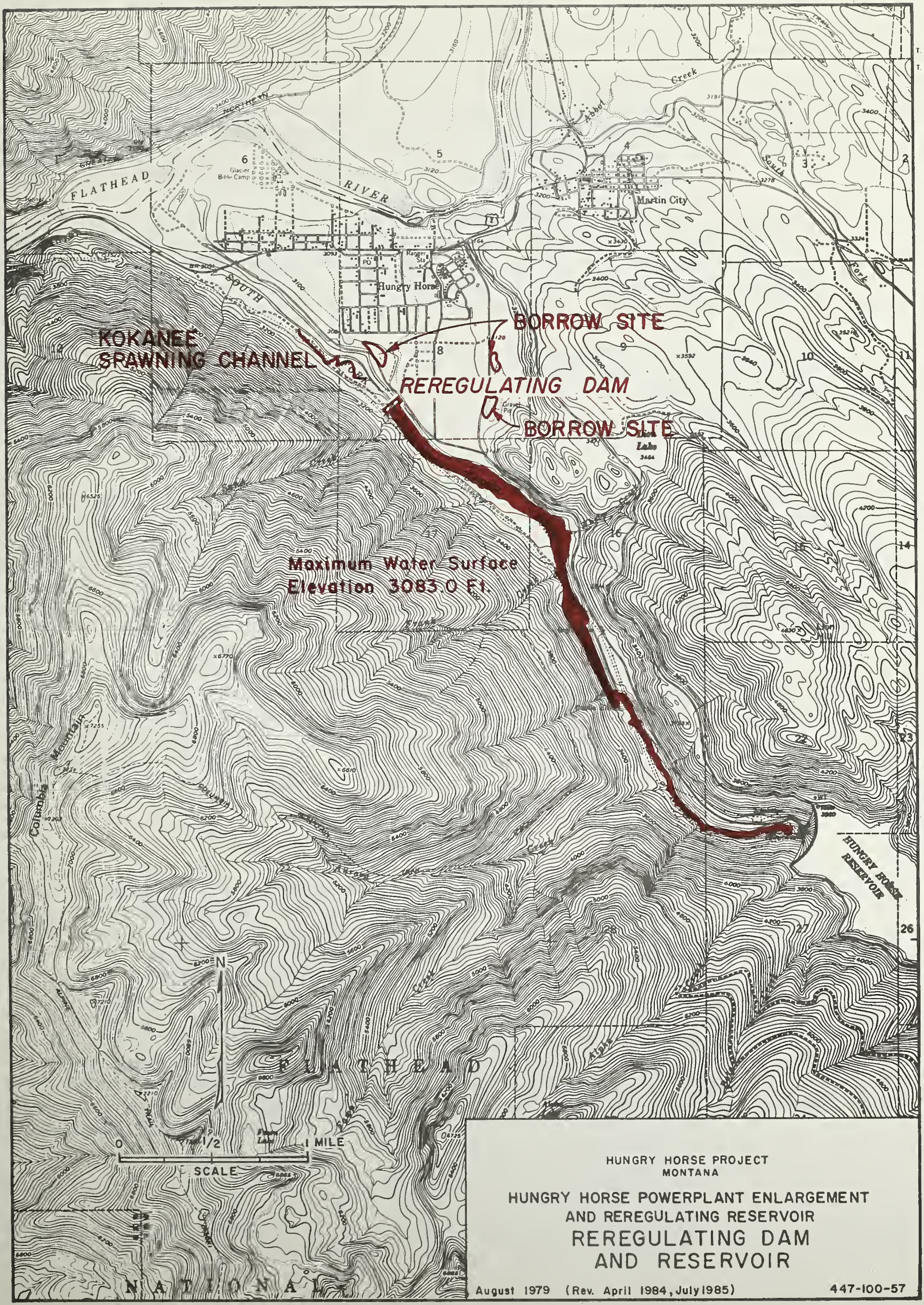
Economic and Financial Analysis

A financial analysis was not prepared for the uprate because the costs of the uprate will be programmed through Reclamation's operation and maintenance program and assigned to the commercial power function of the Federal Columbia River Power System. These costs will be assigned for repayment by the system (that is, BPA) in accordance with public law and administrative procedures. Funds in the amount of $7.4 million have been budgeted in the operation and maintenance program to accomplish the uprate.

REREGULATING RESERVOIR AND KOKANEE SPAWNING CHANNEL

Facilities

The reregulating reservoir damsite is located in the SE1/4SW1/4 sec. 8, T. 30 N., R. 19 W., about 3.3 miles downstream from existing Hungry Horse Dam (see Reregulating Dam and Reservoir map). The dam structure would combine a



HUNGRY HORSE PROJECT
MONTANA

HUNGRY HORSE POWERPLANT ENLARGEMENT
AND REREGULATING RESERVOIR

REREGULATING DAM
AND RESERVOIR

August 1979 (Rev. April 1984, July 1985) 447-100-57

roller-compacted concrete section, serving as the impermeable core of the structure, with a roller-compacted earth section. The dam would be about 67 feet high with a crest elevation of 3087.0 feet above mean sea level, have a crest width of 10 feet, and have a maximum base width of 45 feet.

A spillway consisting of a concrete-lined stilling basin and approach channel and three 25-foot-wide by 16-foot-high top seal gates would be located in the center of the dam structure. Elevation of the spillway crest would be 3030 feet. Spillway capacity at maximum water surface elevation of 3083 feet would be 50,000 ft^3/s, equal to the spillway capacity of Hungry Horse Dam.

The reregulating reservoir would have a minimum capacity of about 11.5 acre-feet at a water surface elevation of 3030.0 feet and a maximum storage capacity of about 3,275 acre-feet at a water surface elevation of 3083.0 feet. Hungry Horse Powerplant operations with the reregulating reservoir would increase the average tailwater height by by about 1 foot, slightly reducing average annual energy production.

Based on conceptual plans, as recommended by the FWS and MDFWP, an artificial spawning channel for kokanee would be constructed on the left bank of the South Fork just below the reregulating damsite. The spawning channel would be about 1,800 feet long and contain about 36,000 square feet of spawning gravels. A bottom width of 20 feet, side slopes of 2:1, and a gradient of 0.0011 feet per linear feet are included in the conceptual design. Water for the channel would be provided at a flow rate of about 20 ft^3/s by pumping from the South Fork at the upper end of the channel. Flow augmentation by gravity diversion from a nearby creek is possible and was included in some conceptual designs, but associated costs are high. Costs for a gravity diversion are not included for this report. A vertical slot fish ladder at the lower end of the channel would provide an entrance for fish. Measures would be included to provide bald eagle perching and feeding opportunities along the spawning channel.

Accomplishments

The reregulating reservoir would be operated to moderate flows from Hungry Horse Powerplant. Large flow releases for short periods of time could be completely controlled as could smaller changes over a longer period of time. This would allow a greater amount of peaking power generation from the powerplant without violating the agreements on flows at Columbia Falls. A yearly average increase of about 113 million kWh of peaking generation would be possible with the reregulating reservoir. However, the total annual average energy generation would be reduced slightly, by about 3,500,000 kWh. Table 5-2 shows a comparison of power production that would be possible with and without the reregulating reservoir. Power estimates assume that generators will be uprated to 428 MW and that operation will meet the present recommended flows at Columbia Falls.

Table 5-2.--Average Annual Power Production with a Reregulating Reservoir

Type of Generation	Amount (kWh) Uprate	Uprate Plus Reregulating Reservoir	Difference
Peak 1/	369,743,000	482,734,000	+112,991,000
Nonpeak 2/	578,857,000	453,366,000	-115,491,000
Total	948,600,000	946,100,000	-3,500,000

1/ Energy component used to follow daily load fluctuations
2/ Total energy minus energy for peaking

Construction and operation of the reregulating reservoir would result in the loss of about 36,000 square feet of spawning gravels, which would be replaced by construction and operation of an artificial spawning channel. Kokanee spawning opportunity and the number of spawning kokanee that serve as a food source for bald eagles in the area should remain unchanged. Some downstream fishery benefits could be expected but would be minor and incidental to the reregulating reservoir operation.

Operation of the reregulating reservoir could also have a positive effect on downstream recreation by reducing water fluctuation. This effect would probably be limited to periods during the summer recreation season when other plants could not meet loads because of unexpected shutdown or lack of water supply. Large fluctuating releases from Hungry Horse Powerplant could be moderated to improve conditions for downstream fishermen.

Economic and Financial Analysis

Table 5-3 shows the costs for developing and operating the reregulating dam and reservoir option. The construction costs, based on a January 1984 price level, are estimated respectively at $27 million for the reregulating dam and $1 million for the spawning channel. Interest during construction, based on a 3-year construction period and 12-3/8 percent interest, would total $5,488,000. A total Federal investment of $33,488,000, repaid over a 50-year repayment period with an interest rate of 12-3/8 percent[1/], would require an annual payment of about $4,156,000. Annual operating costs are estimated at $25,000 for the reregulating dam and $14,800 for the spawning channel. The total annual cost including repayment of the Federal investment would be $4,196,100.

1/ The interest rate for power repayment for fiscal year 1985 as outlined in Department of the Interior Manual 730

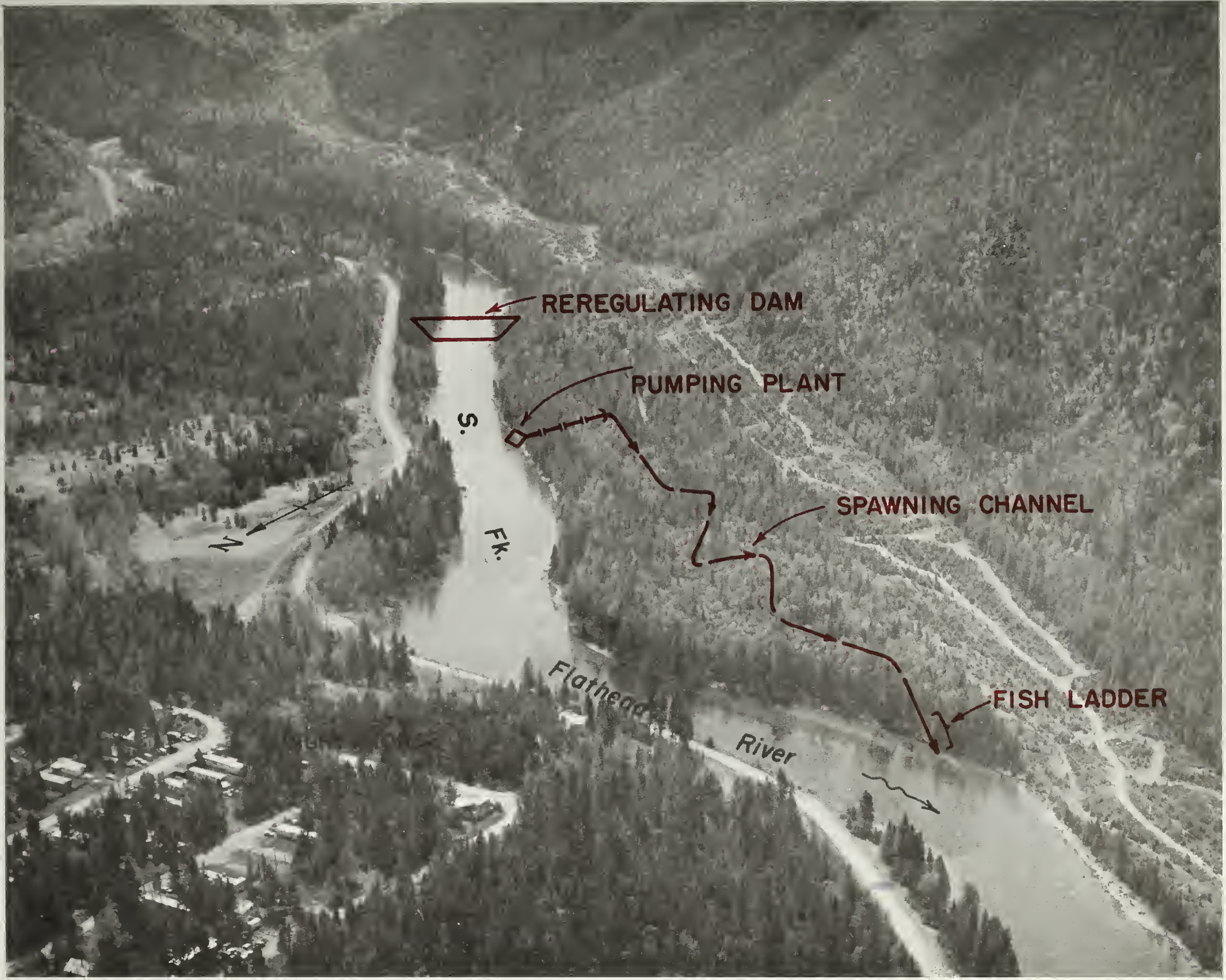

REREGULATING DAM
PUMPING PLANT
SPAWNING CHANNEL
FISH LADDER
S. Fk.
Flathead River
N

Table 5-3.--Federal Investment and Annual Equivalent Costs of the Reregulating Dam Option

Item	Reregulating Dam	Spawning Channel	Total
Construction cost	$27,000,000	$1,000,000	$28,000,000
Interest during construction	5,360,000	128,000	5,488,000
Federal investment	$32,360,000	$1,128,000	$33,488,000
Annual cost			
Investment	$4,016,000	$140,000	$4,156,000
Operation, maintenance, replacement, and power	25,000	14,800	39,800
Total	$4,041,000	$154,800	$4,196,000

A benefit-cost analysis was not prepared for the reregulating dam option. Load-resource analyses made by BPA of electrical power in the Pacific Northwest show that there is no need in the immediate future for increased electrical supplies or generating capability, especially for peaking generation. The reregulating reservoir option could regain the peaking capability lost at Hungry Horse Powerplant as a result of meeting streamflow recommendations. Since there is no need to increase or recover lost peaking capability, calculation of monetary benefits for the reregulating reservoir option would be difficult.

The financial analysis consists of a determination of the repayment requirements for the reregulating dam and spawning channel under power repayment criteria. This assumes that the costs of these facilities would be allocated to commercial power, that any power additions at the Hungry Horse Project would be integrated into the Federal Columbia River Power System, and that all power would be marketed by BPA. Although the downstream fishery and recreation would probably be benefited, any benefits would probably be incidental. All construction costs allocated to commercial power, along with interest during construction, are reimbursable with interest on the unpaid balance at the rate that is applicable in the year construction is begun. The repayment period for commercial power extends 50 years from the first year of commercial service. All allocated operation, maintenance, and replacement costs are also paid by power revenues.

Accordingly, construction costs of $28 million and interest during construction of $5,488,000 would be reimbursable along with the annual operation cost of $39,800. The investment costs (construction cost plus interest during construction) are repayable with interest over a 50-year period at the power repayment rate. The rate in effect for fiscal year 1985 is 12.375 percent. At that interest rate, the annual financial requirement would be $4,196,100.

Based on the cost and power estimates provided in tables 5-2 and 5-3 and on the present differential for valuing peaking generation (2.4 times the cost of other power), peaking power would need to sell at about 65 mills per kilowatt-hour to repay the annual costs of the reregulating dam option. This cost per kilowatt-hour of peaking generation is attractive compared to alternative sources. If an electrical power load-resource analysis for the Pacific Northwest sometime in the future should indicate a need for additional peaking capacity, the reregulating reservoir potential should be considered.

ENVIRONMENTAL CONCERNS

UPRATE

Compliance with provisions of the National Environmental Policy Act (NEPA) for the uprate of the existing powerplant will be made through the project operation and maintenance program. Consultation with the FWS on possible effects on the endangered bald eagle will be included in that process. It is expected that the uprate, which is being performed under project maintenance and operation procedures, will fall within a categorical exclusion. Categorical exclusion is a category of action which has been found to have no significant effect on the human environment. If a categorical exclusion is determined, neither an environmental assessment nor an environmental statement will be prepared. Preliminary evaluation during the feasibility investigation to assess effects of an uprate did not identify any meaningful biological, social, or power production impacts and supports designation of a categorical exclusion. A Fish and Wildlife Coordination Act report was prepared by FWS during the feasibility investigation.

The existing generating units will be uprated over a 4-year period in a staged manner during the regular, annual maintenance period in late spring. One unit each year will be uprated. Power generation will not be reduced since little power is produced by Hungry Horse during the annual maintenance period (the reservoir is being filled) and the three units on line will be capable of generating loads normal for that time of year. As many as 10 additional workers will be needed during the actual construction period, and some increase in traffic on the access road to Hungry Horse Powerplant is expected during the uprate. Onsite disturbance will be minimal since most actual work will be within the powerhouse and materials will be stored within the powerhouse to the extent possible; some changes may be made in the switchyard.

Reclamation intends to continue to cooperate with MDFWP and the NPPC toward meeting recommended flows, during and following the uprate. All releases to meet downstream fishery needs are within the hydraulic capacity of two generating units; spilling of water to meet downstream needs should not be needed during the uprate. The uprate schedule is shown in the "Formulation of Plans" chapter.

Planning and construction of transmission lines to handle the increased power would be the responsibility of BPA. Present projections are that no changes to the transmission line system between Hungry Horse Powerplant and BPA's substation at Columbia Falls will be made as a result of uprating the generators. Based on an added generator capacity of 100 MW, preliminary studies by BPA indicate that the existing transmission line would be adequate with the planned addition of a 75-megavolt-ampere-phase shifting transformer at Hungry Horse to control loading of the 115-kV Hungry Horse-Columbia Falls line. When the current surplus energy situation changes and as costs of electrical energy increase, rebuilding or modifying the transmission system from Hungry Horse may become cost effective. BPA will, at that time, prepare an environmental assessment or statement if the rebuild or modification does not fall within a categorical exclusion.

REREGULATING RESERVOIR

If constructed, the reregulating dam would be located about 3.3 miles downstream from Hungry Horse Dam, and the reregulating reservoir, when full, would extend from the reregulating dam to Hungry Horse Dam. Actual construction would take place over a 3-year period beginning in the third fiscal year after authorization. The area affected during construction of the reregulating dam would be limited primarily to the reregulating damsite, including the area of diversion channel around the damsite, the borrow areas, and the kokanee spawning channel site (see Reregulating Dam and Reservoir map).

Dewatering the reregulating damsite would be accomplished by excavating a channel about 65 feet wide at the base, about 70 feet deep, and about 1,500 feet long through the right abutment of the reregulating dam. Two small cofferdams, one at each end of the excavated channel, would be constructed across the river channel. This design anticipates that Hungry Horse Dam would be used to provide the necessary protection against all floods up to a 25-year frequency. Design of the cofferdams was not specifically addressed at this time because of the low height needed (about 20 feet). To facilitate dewatering, a minimum of 16 deep dewatering wells and associated well points may be necessary because of the pervious nature of the foundation. Excavated materials would be stocked near the site or possibly at the borrow areas for return to the excavated channel. After the dam and gate structures are completed, the diversion channel would be filled with compacted material to approximately the original ground contour.

Aggregate and pervious materials for the reregulating dam would be obtained from three existing borrow sites that were used during construction of Hungry Horse Dam. All of the borrow sites are within 1/2 mile of the reregulating damsite. Use of heavy equipment would be confined primarily to the area bordered by the borrow sites, the reregulating damsite, and the kokanee spawning channel. Construction activities would be minimal during the winter because of cold weather.

The dam structure combines a roller-compacted concrete gravity section with a roller-compacted earthfill embankment. Because the work area for placement of the roller compacted concrete is quite limited, some alternative impermeable core, such as a counterfort wall, may prove more economical during future design. All materials from the required excavation not used in the embankment would be placed as miscellaneous fill in the diversion channel. No seismic analysis has been done, but future design work would include seismic studies.

A Fish and Wildlife Coordination Act report was completed by the FWS. The reregulating reservoir will have a maximum water surface elevation of 3,083 feet. At this elevation, approximately 107 acres of variable wildlife habitats are included in the area of influence upstream from the reregulating dam. Present operations adversely affect 58 acres of the 107 acres that would be affected by reservoir operation, and effects on those 58 acres would not be significantly more adverse with reservoir operation. The remaining 49 acres of terrestrial habitat that would be affected by the reregulating reservoir operation consists predominantly of fir/larch forest with scattered birch and

cottonwood trees. Predominant animal species within this area include white-tailed deer, pine squirrels, and various passerine birds. As discussed in a previous section, bald eagles congregate along this reach and feed on spawning kokanee.

During the 3-year construction period, there would be localized noise and air pollution from equipment operation. Some wildlife would temporarily leave the work area because of these disturbances but would return when construction ended. Kokanee, during this period, would be able to move through the excavated channel to pass the site and spawn upstream. Bald eagles could be affected by construction activities in the area. Disturbance of the borrow areas, which are in close proximity to the town of Hungry Horse, would probably not be significant since there is evidence of current disturbance (removal of materials) and human activity such as off-road vehicle use, target shooting, etc., at these sites. Although some animals may use these sites, the vegetation is sparse and provides limited value.

Long-term effects from construction and operation of the reregulating dam include elimination of kokanee spawning opportunity in the 3.3-mile reach of the South Fork above the reregulating dam (an estimated loss of about 36,000 square feet of spawning gravels). Operation of the reservoir would also result in a loss of about 49 acres of terrestrial wildlife habitat by inundation. Big game migration through the area is very limited and would not be significantly affected.

Loss of fish spawning opportunity, but especially the bald eagle habitat associated with the fishery, would be mitigated by constructing a kokanee spawning channel on the left bank of the South Fork just downstream from the reregulating damsite. The goal of the mitigation is to replace the lost food source for bald eagles and to provide a secure area for feeding and roosting. Wildlife agencies have not proposed direct mitigation to replace the loss of the 49 acres of terrestrial habitat but have recommended that the area of the kokanee spawning facility be developed and managed in a manner that would also benefit other wildlife species. The spawning channel could potentially serve as a local egg source for hatchery production if such a program would be compatible with bald eagle management.

The conceptual plan for mitigation at this time is construction of a spawning channel on a bench approximately 20 feet in elevation above the river surface at the upper end of the channel. The upper end would be located about 1,200 feet downstream from the reregulating damsite. The channel would be about 1,800 feet long and would be lined with spawning gravels of 1/4- to 1-1/2-inch size for a depth of 1-1/2 feet. Water for the channel would be pumped from the South Fork at a rate sufficient to provide a water depth of about 0.75 feet at a velocity of about 1.5 feet per second. Alignment of the channel would be a meandering line through the existing forest. Natural perch trees adjacent to the channel would be selectively protected during construction. The construction period would coincide with the construction period for the reregulating dam.

Operation of the reregulating dam and reservoir would help stabilize downstream flows and reduce the magnitude and incidence of flow fluctuations caused by Hungry Horse Powerplant when the uprated units are used for maximum peaking power production. Reduced streamflow fluctuations would improve aquatic habitat conditions including improved populations of aquatic organisms used by fish for food. All fish species inhabiting the main stem Flathead River would benefit from improved habitat conditions. Wildlife species such as waterfowl, shorebirds, and aquatic mammals that reside along the main stem would also benefit.

If the reregulating dam is further considered for congressional authorization and construction, Reclamation will need to accomplish NEPA compliance. Coordination and consultation with State and Federal regulatory agencies would confirm and update the FWS Fish and Wildlife Coordination Act report findings. Analysis of water quality impacts would be done to comply with the Clean Water Act to assure water quality protection during the construction phase. Consultation under the Endangered Species Act would be necessary to update possible effects on bald eagles and to finalize design specifications for a kokanee spawning channel. As part of the NEPA process and in accordance with Reclamation rules and regulations, the necessary compliance documents would be completed.

A D D E N D U M

BIBLIOGRAPHY OF FISHERY REPORTS

Fraley, J.J. 1984. Effects of the Operation of Hungry Horse Dam on the Kokanee Fishery in the Flathead River System. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Fraley, J.J. and P.J. Graham. 1982. The Impact of Hungry Horse Dam on the Fishery of the Flathead River. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Fraley, J.J. and McMullin, S.L. 1983. Effects of the Operation of Hungry Horse Dam on the Kokanee Fishery in the Flathead River System. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Fredenberg, W. and P.J. Graham. 1982. Census of Kokanee Fishermen on the Flathead River. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Fredenberg, W. and P.J. Graham. 1983. Flathead River Fisherman Census. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Graham, P.J. and W. Fredenberg. 1983. Flathead Lake Fisherman Census. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Graham, P.J., S.L. McMullin, S. Appert, K.J. Fraser, and P. Leonard. 1980. Impacts of Hungry Horse Dam on Aquatic Life in the Flathead River. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

McMullin, S.L. and P.J. Graham. 1981. The Impact of Hungry Horse Dam on the Kokanee Fishery of the Flathead River. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Perry, S. and P.J. Graham. 1981. The Impacts of Hungry Horse Dam on the Aquatic Invertebrates of the Flathead River. Montana Department of Fish, Wildlife, and Parks. Kalispell, Montana.

Perry, S. and P.J. Graham. 1982. Impacts of Hungry Horse Dam on the Invertebrates in the Flathead River - Final Report. Montana Department of Fish, Wildlife, and Parks. Contract 9-07-10-S1070. Kalispell, Montana.

Sutherland, R. 1982. Recreation and Preservation Valuation Estimates for the Flathead River and Lake System, in Conjunction with Montana Department of Fish, Wildlife, and Parks, Flathead River Basin Environmental Impact Study. Environmental Protection Agency.

FISH SPECIES OCCURRING IN FLATHEAD LAKE AND THE FLATHEAD RIVER UPSTREAM FROM FLATHEAD LAKE AND THEIR RELATIVE ABUNDANCE
C--Common, U--Uncommon, R--Rare, N--Not Known to Occur
(Courtesy of Montana Department of Fish, Wildlife, and Parks)

Fish Species	Abundance: North and Middle Forks, Flathead River	Main Stem Flathead River	Flathead Lake
Cutthroat trout			
Westslope (*Salmo clarki lewisi*) 1/2/	C	C	C
Yellowstone (*Salmo clarki bouvieri*)	R	R	R
Bull trout (*Salvelinus confluentus*) 1/3/	C	C	C
Rainbow trout (*Salmo gairdneri*)	R	U	R
Brook torut (*Salvelinus fontinalis*)	U	R	R
Lake trout (*Salvelinus namaycush*)	N	R 4/	C
Kokanee (*Onchorhynchus nerka*)	C 4/	C 4/	C
Lake whitefish (*Coregonus clupeaformis*)	N	U 4/	C
Pygmy whitefish (*Prosopium coulteri*)	N	U 4/	C
Mountain whitefish (*Prosopium williamsoni*) 1/	C	C	C
Arctic grayling (*Thymallus arcticus*)	R	R	N
Slimy sculpin (*Cottus cognatus*) 1/	C	C	C
Shorthead sculpin (*Cottus confusus*) 1/2/	C	C	?
Mottled sculpin (*Cottus bairdi*)	?	?	?
Longnose sucker (*Catastomus catostomus*) 1/	U	U	C
Largescale sucker (*Catostomus macrocheilus*)	C	C	C
Peamouth (*Mylocheilus caurinus*) 1/	N	C	C
Northern squawfish (*Ptychocheilus oregonensis*) 1/	U	C	C
Northern pike (*Esox lucius*)	N	R 5/	R
Redside shiner (*Richardsonius balteatus*) 1/	N	R 5/	C
Largemouth bass (*Micropterus salmoides*)	N	R 5/	U
Pumpkinseed (*Lepomis gibbosus*)	N	R 5/	C
Yellow perch (*Perca flavescens*)	N	R 5/	C
Black bullhead (*Ictalurus melas*)	N	R 5/	R

1/ Native species
2/ Species of special concern
3/ Bull trout is the term currently used for the inland form of Dolly Varden, a costal anadromous fish.
4/ Refers to seasonal abundance
5/ Common in some sloughs along the lower river